REMARKS

Claims 1-20 are pending in the application, are rejected, and are at issue.

By this Amendment, applicant has amended the specification at page 2, line 16, where requested. Applicant otherwise traverses the objection to the drawings, the specification and the rejection of the claims under §112 as being based on a non-enabling disclosure.

The rejection is focusing on the issue of controlling loop current. How loop current is controlled is not what the invention is about. Any number of methods can be used to create and control a 4-20mA current loop. The invention relates particularly to how a designer recognizes the challenge of using available loop current to power the device that controls the current loop.

As described with respect to the background of the invention for this application, a two-wire transmitter includes two terminals connected to a remote power source. The transmitter loop current, drawn from the power source, is proportional to the process variable being sensed. A typical instrument operates off of a 24 volt DC source and varies the signal current in the loop between 4mA and 20mA DC. Because of these operating requirements, the design of the transmitter in terms of power consumption is critical. For example, when a low level signal of 4mA is transmitted, there is minimal power available to be consumed by the instrument. Therefore, circuits must be designed to operate off of such minimal available power.

The invention relates to a loop powered process instrument which makes optimum use of minimal available power. To aid in the understanding of the invention, applicant submits herewith a copy of the drawing figures showing in red a proposed correction to the drawing with

respect to the placement of reference numeral 10 and blue highlighting to illustrate the process loop.

As described in the specification, a process loop 10 uses a loop powered process instrument 12. The instrument 12 is connected to a remote power source 20 by two wires 22 and 24, thus the name two-wire loop. The power source 20 is typically about 24 volts DC and the instrument 12 varies signal current on the loop between 4mA and 20mA DC. See page 5, line 16 to page 6, line 3.

The instrument 12 can be used to sense numerous different process variables and is not intended to be limited to any particular type of instrument or measurement technique. See page 6, lines 4-8.

A control circuit 26 measures the process variable using the primary element 14 and develops a control signal on a line 36. An output circuit 28 controls current on the loop 10 in accordance with the control signal on the line 36. A power supply circuit 30 is connected to the output circuit 28 and the control circuit 26 for receiving power from the loop 10 and supplying power to the control circuit 26. See page 6, lines 9-18.

The output circuit 28 is <u>conventional in nature</u> and includes a control block 38 in series with a sense resistor R and the power source 20. See page 7, lines 9 and 10. This series connection is highlighted in blue in the attached figure. This series connection comprises the process loop 10 described in the specification. The control block 38 receives the process variable signal, on the line 36, and controls the 4-20mA loop current in proportion to the measured process variable, <u>as is well known</u>. See page 7, lines 12-14. The control block 38 is also

connected across the sense resistor R to sense loop current <u>in the conventional manner</u>. See page 7, lines 10 and 11. Particularly, as is apparent, the loop current flows through the resistor R. The control block 38 being connected across the resistor can measure the voltage across the resistor which is equal to the current times the resistance.

The present invention uses charge pump circuits 32 and 34 cascaded to provide a three volt DC supply to the control circuit 26. See page 8, lines 4 and 5.

Thus, the invention provides a high efficiency power supply circuit operating off of low power input using cascaded charge pump circuits, see page 11, lines 3-5.

35 U.S.C. §112 requires that the specification contain a written description of the invention to enable any person skilled in the art to make and use the same. Applicant submits that the methods and techniques for controlling loop current are conventional and well known to those skilled in the art, as stated in the specification, and greater details in the specification is not required. Indeed, the invention is not directed to how loop current is controlled, but rather to a power supply circuit as part of a loop power process instrument that controls loop current. Applicant submits that the specification and drawings are sufficient to enable one skilled in the art to understand the teachings of an output circuit for connection to a two-wire process loop for controlling current on the loop in accordance with the control signal, as recited in, e.g., claim 1.

As evidence of the general knowledge of those skilled in the art, applicant previously submitted a third party reference entitled "4-20 mA Current Loop Primer" discussed on page 5 of the action. This reference illustrates that controlling loop current is conventional

and well-known. Indeed, the reference on the first page under the heading "Why Use A Current Loop?" states:

> "The 4-20mA current loop shown in Figure 1 is a common method of transmitting sensor information in many industrial process-monitoring applications."

Whether or not the element depicted in Figure 1 thereof is a comparator is not known, nor is it relevant. What is important is the reference to such a current loop being a common method. The second page of the reference, second paragraph, states that "[t]he transmitter amplifies and conditions the sensor's output, then converts this voltage to a proportional 4-20mA DC current that circulates within the closed series-loop".

Submitted herewith is a magazine article entitled "4-20mA Transmitters Alive and Kicking", October 1998, Control Engineering. Control Engineering is a widely recognized publication in the instrumentation field. This article describes the use of 4-20mA current loops. Of significance is the opening statement in the article as follows:

> Because they've been around so long, everyone already knows all there is to know about 4-20 mA transmitters and how to install them.

The article otherwise goes on to discuss some basic issues in such transmitters. Again, this article supports the notion that one skilled in the art will recognize how to control a 4-20mA current loop.

Finally, submitted herewith is an Application Note AN104 of Dataforth Corporation entitled "4-20 mA Transmitters". The opening line of this document, under the heading "Preamble" reads as follows:

> Over the years the 4-20 mA transmitter has become an accepted standard technique for transmitting information between field I/O and the control area.

Fig. 3 on the second page of the Dataforth reference shows the basic circuit blocks of a 4-20mA transmitter with a current source conversion circuit which establishes the current loop signal and the loop side power which generates the necessary internal voltages. In the present invention, element 28 corresponds functionally to the current source conversion circuit and the cascaded charge pump circuits 32 and 34 provide the loop side power.

Turning to the claims, claim 1, e.g., specifies a loop powered process instrument comprising a control circuit measuring a process variable and developing a control signal representing the process variable. An output circuit for connection to a two-wire process loop controls current on the loop in accordance with the control signal. A power supply circuit is connected to the output circuit and the control circuit for receiving power from the two-wire process loop and supplying power to the control circuit, comprising cascaded charge pump circuits.

At issue is whether or not the specification is enabling for an output circuit for connection to a two-wire process loop for controlling current on the loop in accordance with the control signal. Applicant submits that the disclosure is enabling.

The test for enablement is described in MPEP §2164.01. The test requires the invention be enabled so that any person skilled in the art can make and use the invention without undue experimentation. The patent need not teach, and preferably omits, what is well known in the art. Moreover, MPEP §2164.04 specifies that:

> A specification disclosure which contains a teaching of the manner and process of making and using an invention in terms which correspond in scope to those used in describing and defining the subject matter sought to be patented must be taken as being in compliance with the enablement requirement of 35 U.S.C. 112, first paragraph, unless there is a reason to doubt the objective truth of the statements contained therein which must be relied on for enabling support.

Further, as the Federal Circuit stated with respect to Section 112 in Atmel Corp. v. Information Storage Devices, Inc., 53 USPQ2d 1225, 1230 (Fed. Cir. 1999):

> Paragraph 1 permits resort to material outside of the specification in order to satisfy the enablement portion of the statute because it makes no sense to encumber the specification of a patent with all the knowledge of the past concerning how to make and use the claimed invention. One skilled in the art knows how to make and use a bolt, a wheel, a gear, a transistor, or a known chemical starting material. The specification would be of enormous and unnecessary length if one had to literally reinvent and describe the wheel.

In the context of the claimed invention, control of current on a two-wire process loop is like the wheel. It need not be reinvented or described. The present application describes that the invention can be used with different sensing techniques and used with conventional

circuitry for controlling loop current. There is no reason to doubt the truth of these statements. Nor has the Examiner set forth why these statements should be doubted. Indeed, these statements of applicant are supported by the multiple industry publications of record herein which describe that a transmitter for a current loop is common, everybody knows all there is to know about 4-20mA transmitters and 4-20mA transmitters have become an accepted technique for transmitting information.

As is apparent, this application need not teach to those skilled in the art that which is well known to them, i.e., controlling current on a two-wire process loop in accordance with a control signal. Indeed, the invention is not directed particularly to how the current is controlled, but rather in an instrument that controls loop current a power supply supplying power to a control circuit.

Summarizing, and responding to the discussion on page 8 of the action, the figures in the application are accurate. Moreover, what is conventional and well known to those skilled in the art is evidenced by the various documents cited herein.

For the above reasons, applicant submits that the objection to the specification and drawings should be withdrawn and likewise the rejection of the claims under §112, first paragraph, should be withdrawn.

If any questions remain with respect to an understanding of the disclosure and claims, applicant's attorney invites the Examiner to contact applicant's undersigned attorney.

Reconsideration of the application and allowance and passage to issue are requested.

Respectfully submitted,

Date: May 24, 2006

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APPLICATION NOTE

DID YOU KNOW ?
In 1827 Georg Simon Ohm, a German physicist, published his work, *The Galvanic Chain, Mathematically Treated*, which was the basis of "Ohm's Law". Ohm's work was initially denounced by critics of the time as a "web of naked fancies"; nonetheless, during his lifetime, he did receive the credit and fame his efforts deserved. In his honor, the unit of electrical resistance bears his name, Ohm.

4-20 mA Transmitters

Preamble

Over the years the 4-20 mA transmitter has become an accepted standard technique for transmitting information between field I/O and the control area. New network type transmission schemes are trying to become "the" standard. Meanwhile there are thousands of I/O points and associated control components that will continue to use the analog current loop method for transmitting data.

Figure 1 illustrates four basic steps inherent in a process control system. First, data is extracted from the process, followed next by analytical examination and interpretation. Once data is properly interpreted, the next step is a decision on the appropriate action. Lastly, the necessary action must be implemented. The distribution of these steps depend on process layout and the control philosophy adopted.

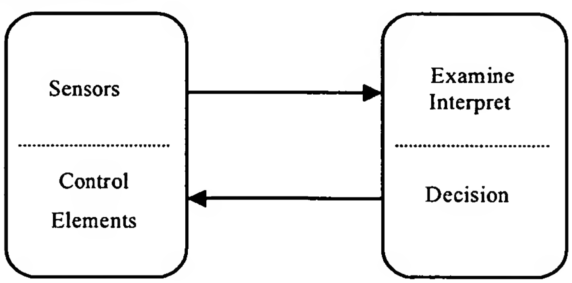

Figure 1
Basic Process Control System

Most all process control systems are distributed throughout a plant site and information flow may be over long distances. Transmitting data over considerable distances often causes major problems in distributed process control systems.

Transmitting data reliably has prompted many different communication schemes and associated products, some of which employ smart electronics in the I/O sensors and control elements.

Long before the "electronic age", process control was dominated by pneumatics. Ratio controllers, PID controllers, actuators, and recorders were all pneumatic. The standard was a 3 to 15 psi pneumatic signal, where 3 psi was the "live" zero. As computer process control began to evolve in the early 1950's, the signal transmission technique shifted from 3-15 psi to 4-20 mA signals., where 4 mA was the "live" zero. A "real" dead zero has always been an alarm condition.

The 4-20 mA Transmitter

A simplified current loop is schematically shown in Figure 2. An ideal Norton current source composed of Isignal, and Rsignal models the 4-20 mA transmitter. The line resistance is shown as Rline, and Vnoise represents random induced loop noise. In this example, a 500-ohm controller and a 250-ohm digital display are connected in series with the signal current. The loop is powered by a 24 volt dc supply.

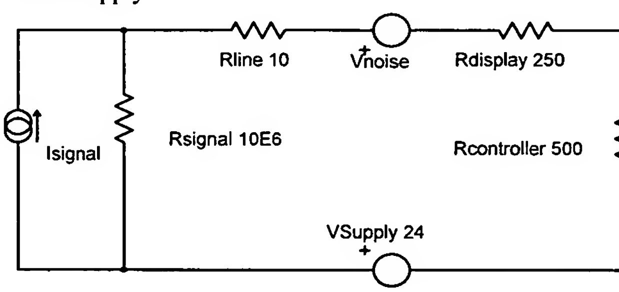

Figure 2
Current Loop Schematic

Several advantages of this type current loop are as follows;

- Signal voltage at any load is (Isignal * Rload), which is independent of supply voltage variations and line resistance (Rline).
- Random induced loop noise voltage at any load is;

  Vnoise * (Rload)/(Sum all Rloads + Rline +Rsignal)

Note that loop noise at a load is reduced by the factor; (Rload)/(Sum all Rloads + Rline +Rsignal). In this example, a 10 volt induced loop noise voltage appears at the controller input as a 0.5 mV error. The controller is a 10 volt FS device (20mA * 500Ω =10) and 0.5 mV represents an error of 0.005 %.

- Supply voltage variations are reduced at any load by the same factor as shown above.
- Multiple loads can be series connected in a transmitter loop, providing considerable control and display opportunities. Loads today typically have full scale input requirements of 1 volt, 5 volts, and 10 volts. Typical 4-20mA transmitters require a voltage across their output terminals to maintain the device within its operational specifications. This voltage is often referred to as "compliance voltage" and has a rather wide range. For example, in Figure 2 the loop voltage (compliance) available for the transmitter is; (Vsupply – all load FS voltages - line IR drops); specifically, (24 volts – 15 volts - 2 mV). Depending on transmitter specifications, a larger supply voltage may be required or perhaps a 5 volt (250 Ω) controller.

  It is noteworthy to observe that selecting a supply needs to be consistent with the number and type of series loads and the required 4-20 mA transmitter "compliance" voltage.

Multiple series loads, wide variation in supply voltage, and some inherent noise immunity are advantages of current loop transmitters.

Figure 3 shows the basic internal circuit blocks of a 4-20 mA transmitter. These circuits provide the following functionality;

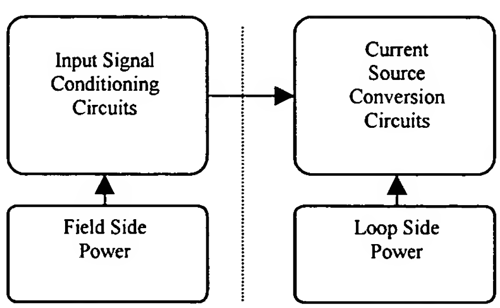

Figure 3
Basic 4-20 mA Circuit Functions

- Input Signal conditioning circuits provide appropriate interfacing for all types of inputs, such as; thermocouples, RTDs, AC-DC voltages and currents, strain gauges. Many 4-20 mA modules have "smart" signal conditioning functionality that provide linearization, and mathematical manipulations.
- Power circuits generate all the necessary internal voltages required and are energized from either a local power source or the actual current loop.
- Current conversion circuits establish the 4-20 mA current loop signal.
- The dashed line in Figure 3 illustrates isolation between the field side and the output loop side. Isolation is an extremely important aspect of signal transmission. Signal loops, power supplies, and grounds should always be completely isolated from each other.

Standards and Definitions for 4-20 mA Transmitters

The American National Standards Institute (ANSI) and The Instrumentation Systems, and Automation Society, (ISA) have numerous documents on signal transmission including 4-20 mA transmitters. See References at the end of this article for more details.

The following was taken from; ANSI/ISA-S50.1-1982 (R1992) *Compatibility of Analog Signals for Electronic Industrial Process Instruments.*

Type numbers with suffix letters are used as transmitter identifiers. Type number is the number of wires necessary to provide transmitter power. Shields and IO wires are excluded. Suffix letters identify the load resistance capability.

Figure 4 illustrates three basic transmitter types.

- Type 2 is a 2-wire transmitter energized by the loop current where the loop source voltage (compliance) is included in the receiver. The transmitter floats and signal ground is in the receiver.
- Type 3 is a 3-wire transmitter energized by a supply voltage at the transmitter. The transmitter sources the loop current. Transmitter common is connected to receiver common
- Type 4 is a 4-wire transmitter energized by a supply voltage at the transmitter. The transmitter sources the loop current to a floating receiver load.

If a transmitter has field inputs, which provide signals referenced to field grounds potential ground loops exist. This potentially will cause signal gradation.

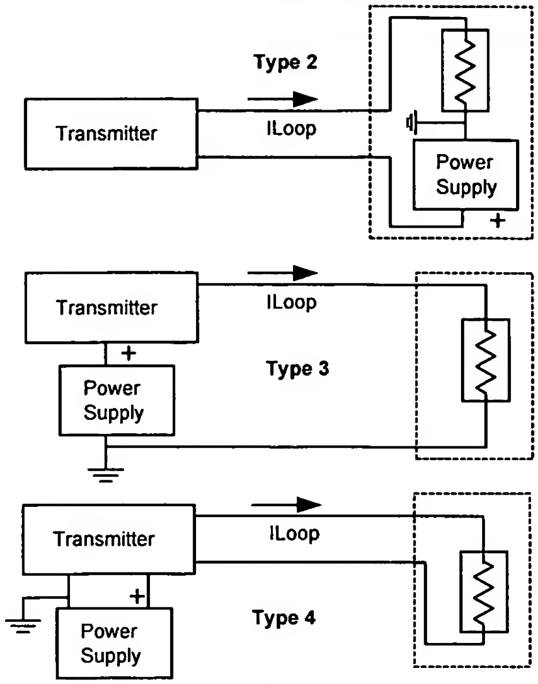

Figure 4
Transmitter Types

Table 1 shows transmitter class designations. It is necessary to understand that all 4-20 mA transmitters may not necessarily be identical in their ability to provide current into different loads. For example, a typical 4-20mA transmitter module could not drive a 100k-ohm load. This would require a compliance source of 2000 volts (20mAx100kΩ). The class standard ensures that modules of identical classes are interchangeable with respect to their drive capabilities. It is noteworthy to mention here that one should always completely examine all module specifications before replacing units.

Table 1
Class Designations

	Class L	Class H	Class U
Load Resistance Minimum	300	800	300 to 800
Supply Voltage Minimum	23	32.7	23 to 32.7

Practical 4-20 mA Circuit

Field inputs are usually referenced to field grounds or in some cases actually connected to a field ground (for example, the grounded thermocouple). Receiver grounds are rarely identical to field grounds; therefore, isolation is required to eliminate potential ground loop problems. Figure 5 illustrates Dataforth's basic block diagram concept of isolated 2-wire current loop transmitters.

Dataforth's transmitters provide;

- Transformer isolation of signals and power
- 2-wire loop powered current transmission (receiver supplies only compliance voltage)
- Field surge suppression, protection, and excitation
- Input and Output Low Pass Filtering
- Output surge suppression, protection
- Data linearization and manipulation

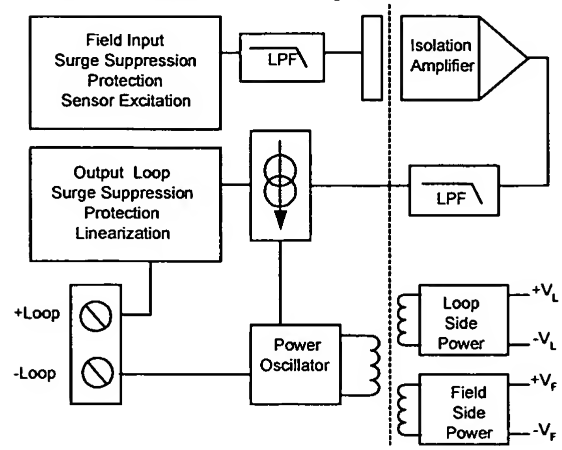

Figure 5
Dataforth Basic Isolated Current Transmitter

The reader is encouraged to visit Dataforth's website www.Dataforth.com for complete detail information on all Dataforth's product and additional application information.

For specific Dataforth 4-20mA-loop products, visit the following links:
http://www.dataforth.com/catalog/doc_generator.asp?doc_id=390
http://www.dataforth.com/catalog/doc_generator.asp?doc_id=364
http://www.dataforth.com/catalog/doc_generator.asp?doc_id=472

Listed below are some additional references.

References:

1. ANSI/ISA-50.1-1982 (R1992) formerly ANSI/ISA-S50.1-1982 (R1992) *Compatibility of Analog Signals for Electronic Industrial Process Instruments*
2. http://www.ISA.org/
3. http://www.ANSI.org/
4. http://www.nssn.org/
5. *Control Engineering* http://www.controleng.com/archives/1998/ctl1001.98/10a929.htm#List